SMART GRIDS THAT POWER OUR CARS

40 YEARS
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#CreatingTheEnergyFuture


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Dr. Robert Kohrs

Fraunhofer Institute for Solar Energy Systems ISE

Division Power Electronics, Grids and Smart Systems

B2G Roundtable Chile

Freiburg, 20. January 2022

www.ise.fraunhofer.de

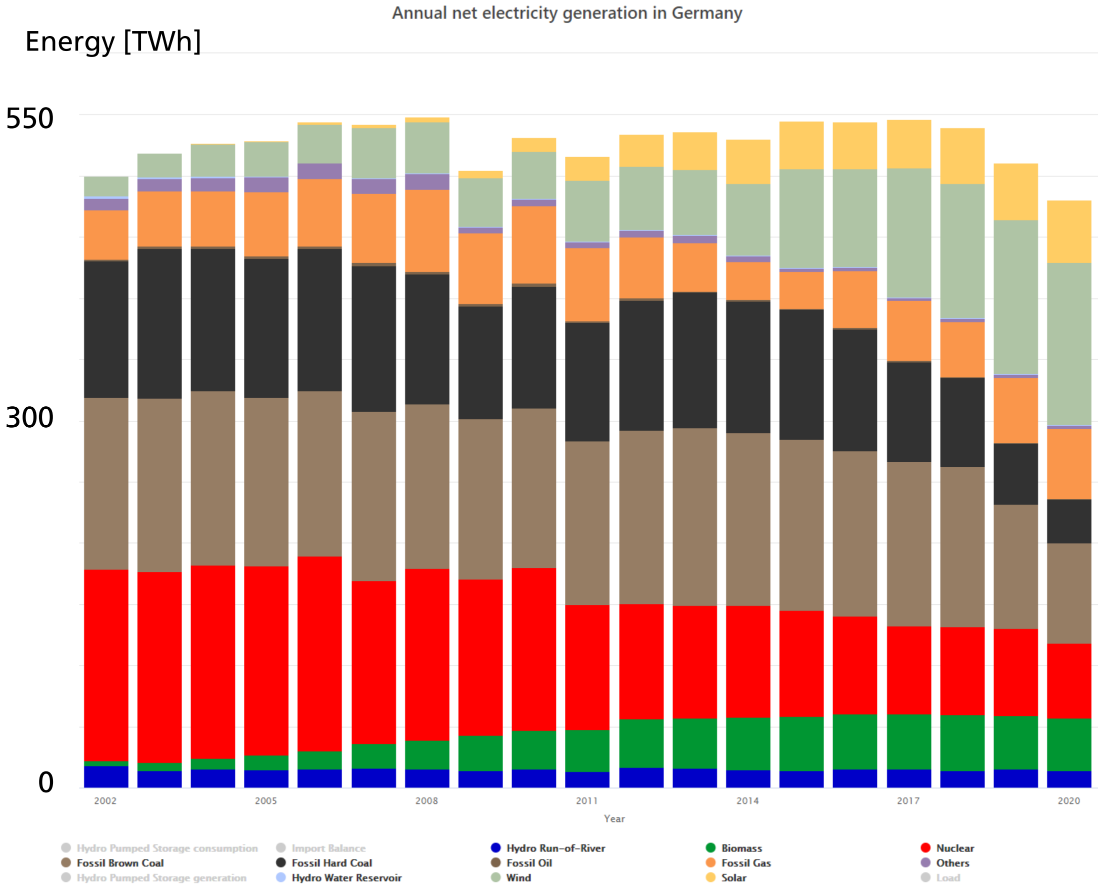
Power vs. Energy

Energy

- 40 mio cars **x** 14.000 km/yr **x** 18 kWh/ 100km ≈ **100 TWh/yr**
- Total electrical energy in Germany 2019 ≈ **500 TWh/yr**

Storage Potential

- 20 kWh x 40 mio cars = **800 GWh**
- Total electrical energy in Germany 2019 ≈ **1.600 GWh / day**



https://energy-charts.info/

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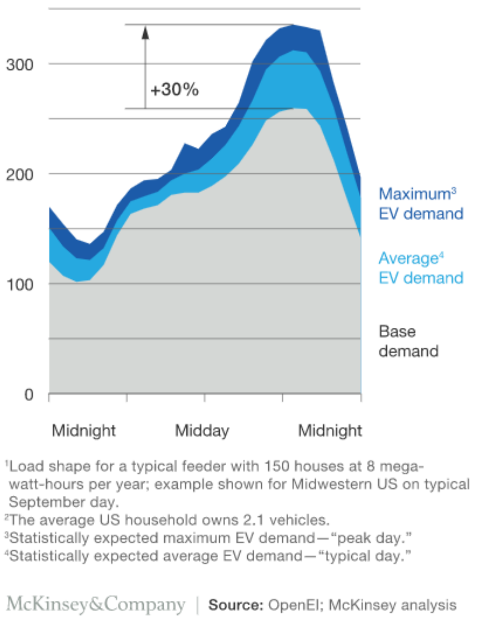
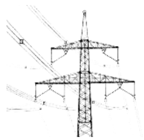
Power vs. Energy





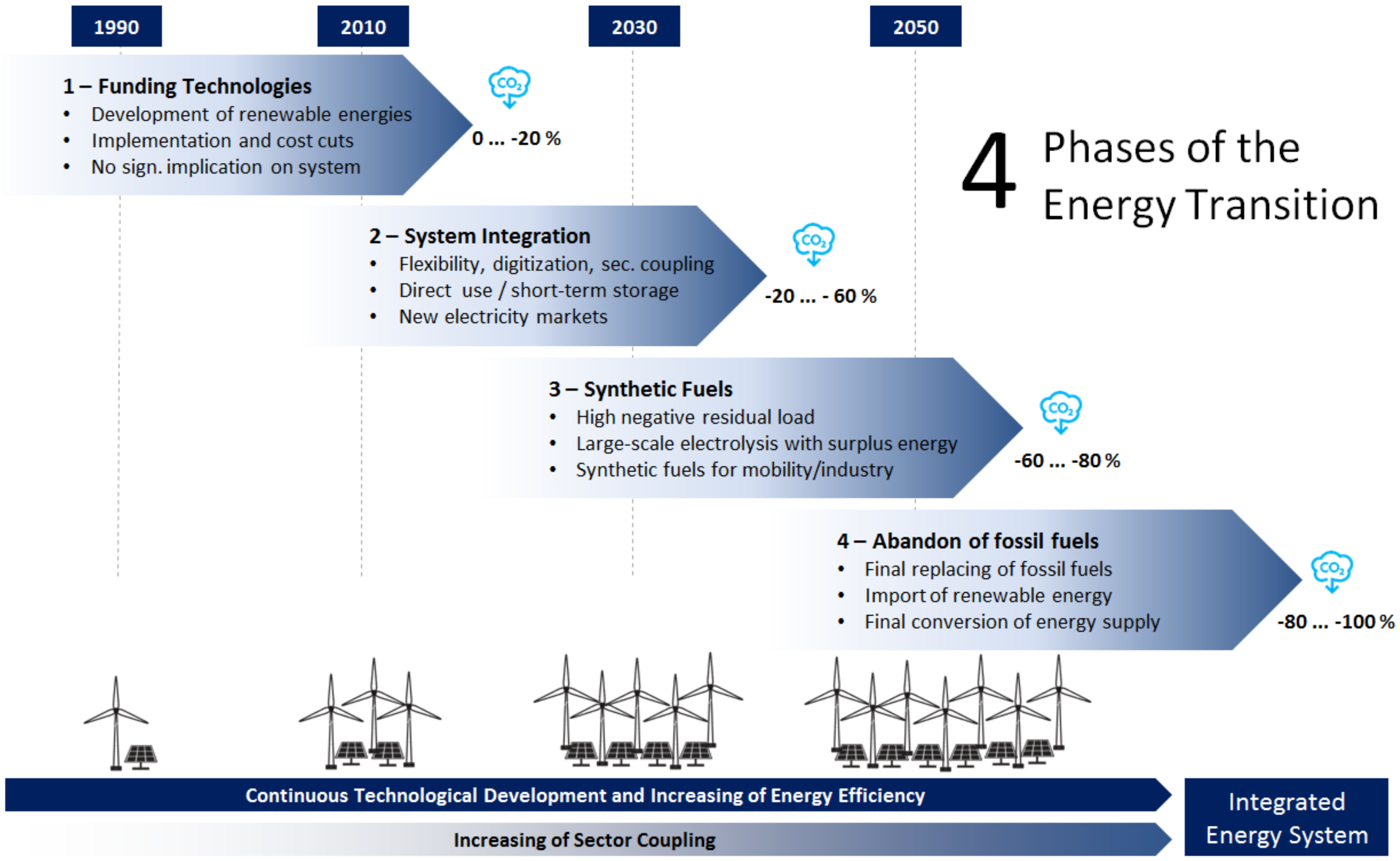
Power

- Charging power is in the range of
  - 2-40 kW for AC charging stations
  - 50-350 kW and much more for DC quick charger
- Charging after 100 km takes between 9 hrs and 3 minutes

Peak Power

- 11 kW x 40 mio cars x 20 hrs/day availability = **366 GW**
- Power German electricity grid **40-80 GW**

Transforming the Power Systems
Digitalization is Powerful Enabler



- From phase 2 on, grids must bring renewables into other energy sectors
- Digitalization will enable required flexibility and new electricity markets

Source: Fraunhofer ISE

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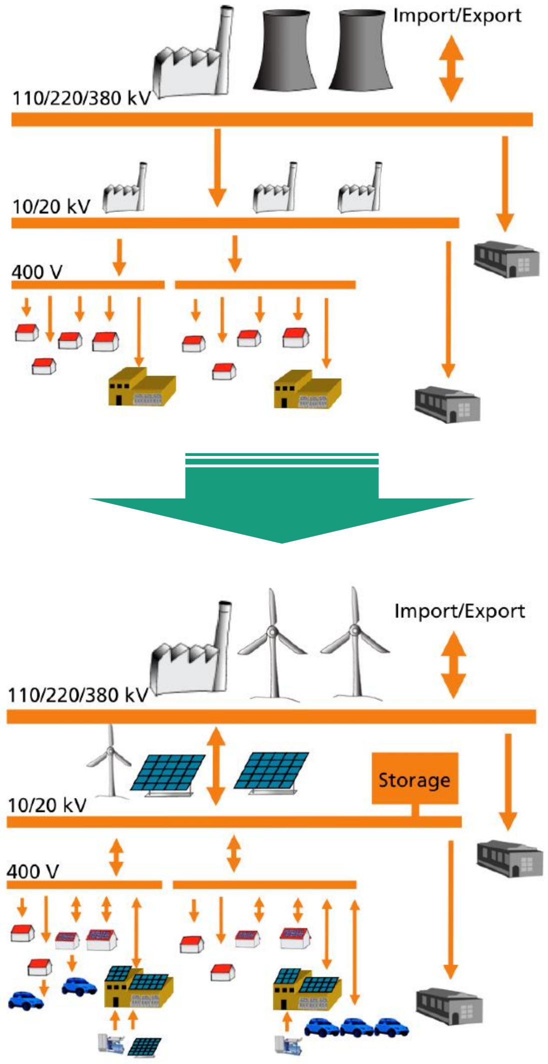
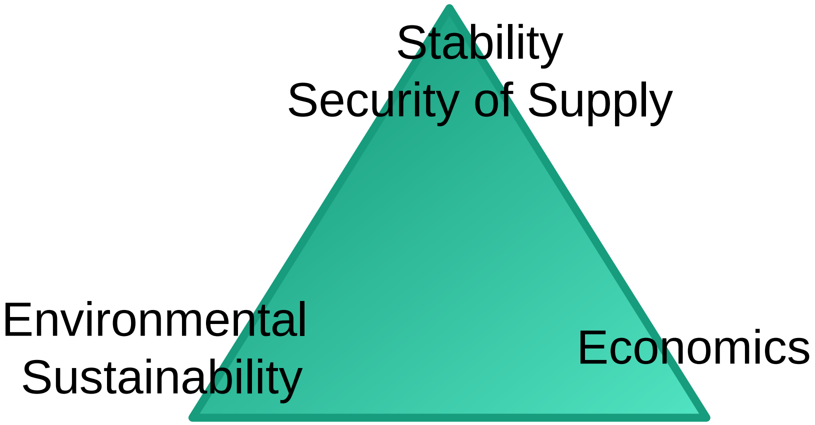
Future Power Grids
Distributed Smart Grids

- Volatile generation of renewable energy requires **new approach** of **load balancing** and **grid operation automation**
  - Storage
  - Demand side management, load flexibility
  - Inertia and reserve control based on power electronics
  - IT solutions (communication, sensors)
  - Automation (forecasts and control) of millions of relevant operating resources
- Acceptance of change and cost by customers through **participation**
- New regulation, **energy markets** and business models



Future Power Grids
Challenges



- Minimize Cost of Transformation
- Minimize Grid Enhancement
- Minimize Congestion of Generation
- Minimize Conversion losses
    - **Grid Operation close to Capacity Limits**
    - **Active Management of Power Flows**
- Maximize Efficiency
- Maximize Automation

Grid Integration of Electric Vehicles

Grid Integration Levels of Charging Infrastructure for Electric Vehicles

Grid-compliant Charging

- EV and EVSE are compliant with local requirements, guidelines and regulation
- Grid to EV only
- Maximum charging power is approved and permanently limited by DSO

Controlled Charging

- Charging can be controlled regarding power and schedule remotely by DSO (with highest priority), CPO, EV user, EV or home energy management system (HEMS)
- Aggregation of charging spots

Bidirectional Charging

- Energy transfers between EVs battery and home / costumer system
- Supports behind the meter (BTM) use-cases
- Energy transfers are motivated by sustainability or economical reasons (e.g. self consumption)

Autonomous Charging

- Charging infrastructure automatically reacts on grid status (voltage, reactive power, etc)
- Flexibility is forecasted and charging schedule adapts to grid services and energy market, economic interests of the EV owner

Today | 2020 | 2025 | 2030

Grid connection → Grid integration

Based on: CharIn Charging Interface Initiative e.V.

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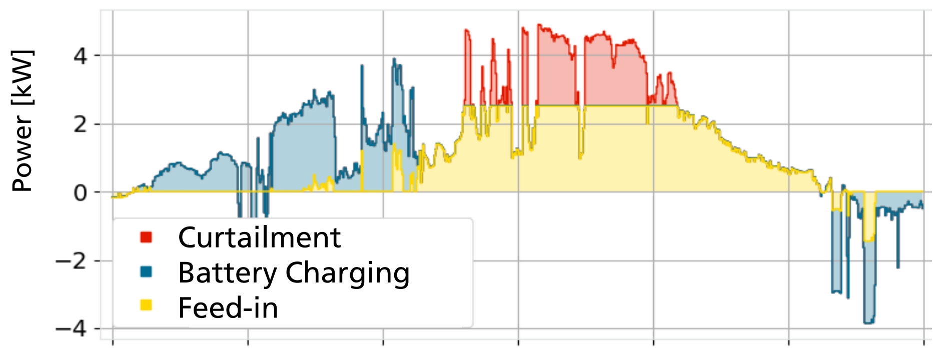
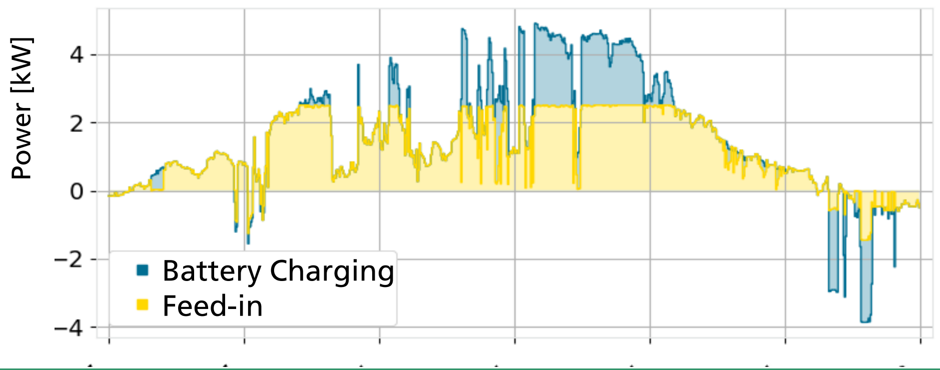
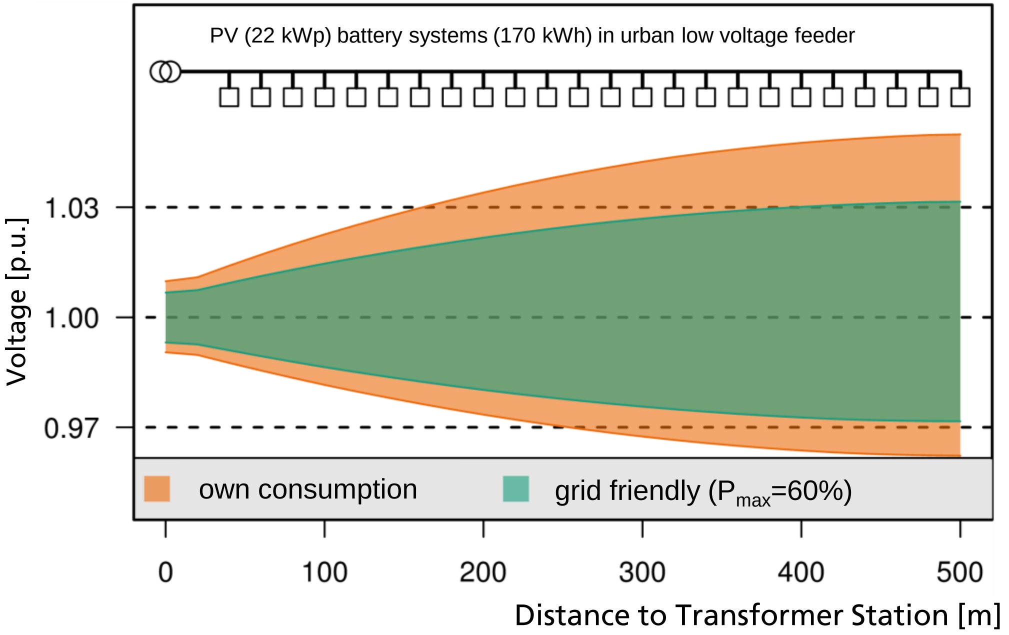
Grid-friendly Operation of ~~PV Battery Systems~~ Electric Vehicles

Own Consumption Optimized



Grid friendly



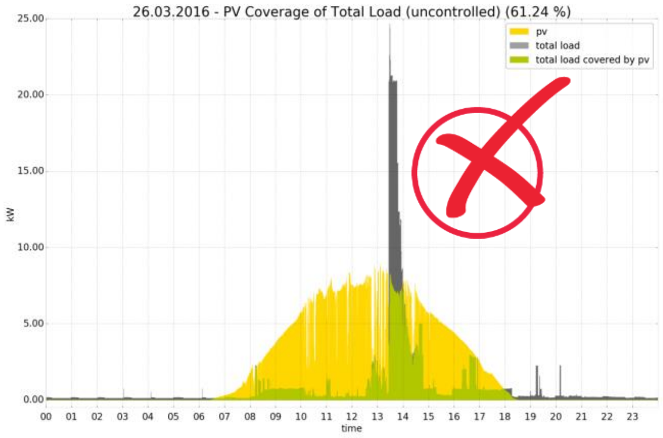


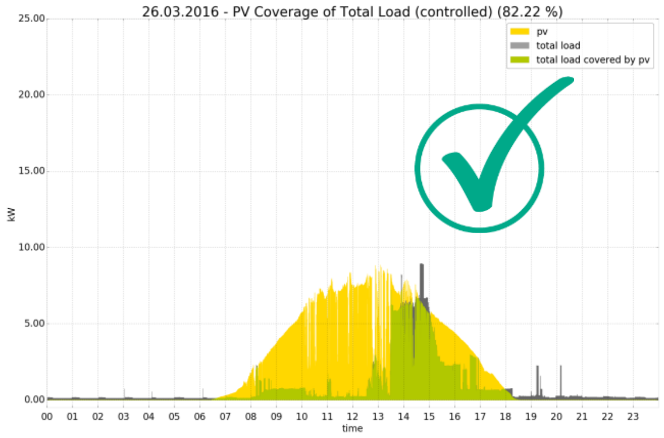
- Own consumption optimization does not automatically avoid grid peaks
- Grid friendly operation: up to 66% surplus PV can be installed

Smart Charging @ Home
Empowering Grid and Infrastructure

- Own Consumption maximization and (in future) peak management using **Home Energy Management Systems**
- Plug and Charge automation

  Considering battery SoC and user preferences





openMUC

www.openmuc.org

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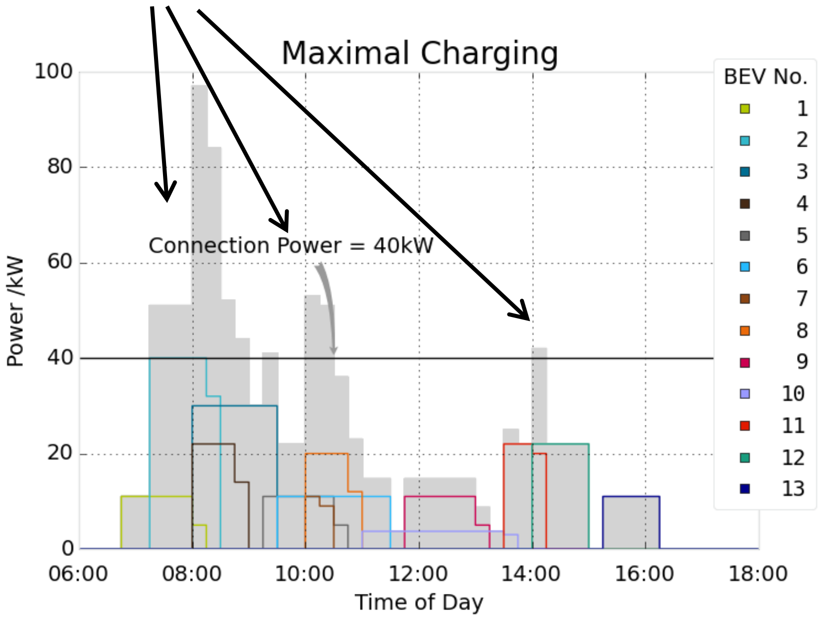
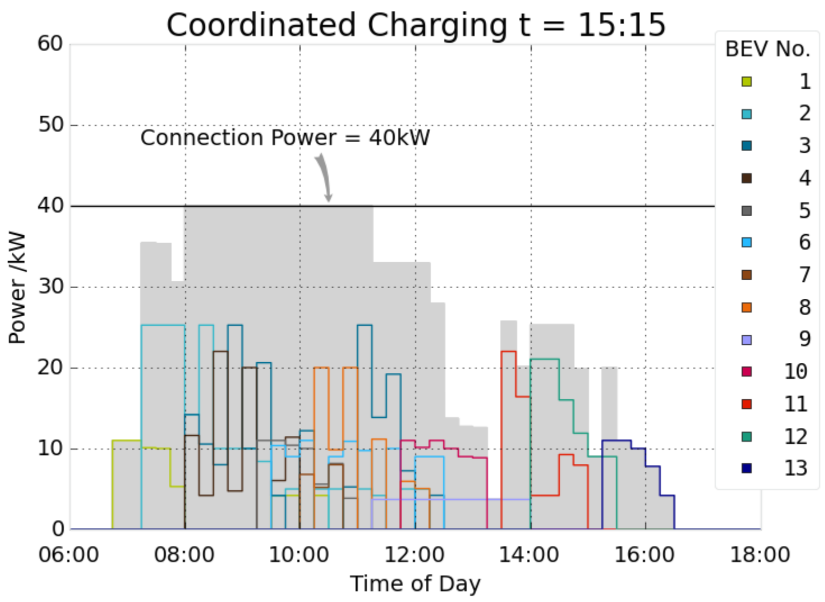
Control Algorithms
Peak Management, Congestion Management

- Interface to Grid Operator
- Energy markets
- Local Control

uncontrolled charging: connection power exceeded!



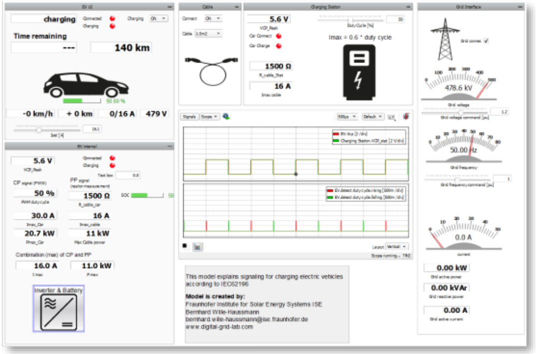
controlled charging: power limits and all user requirements met



Vehicle to Home, Vehicle to Grid
Close to Breakthrough?

- Application interesting for PV own consumption maximization and peak management
- Pooling of cars allows for energy market offerings like control reserve
- Few V2X cars available but many models announced for 2022

- Communication Protocols
  - Supply Equipment to EV: ISO 15118-20 is specified
  - Backend to Supply Equipment: OCPP 2.1 in progress
- Regulation and Clearing are not standardized on international level
- Test facilities for grid integration use-cases
  www.digital-grid-lab.com



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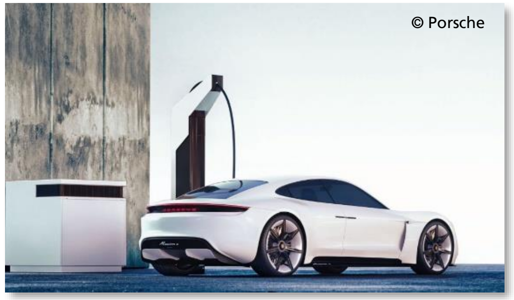
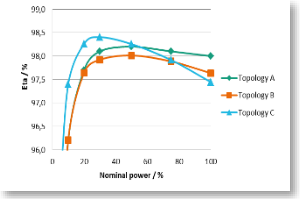
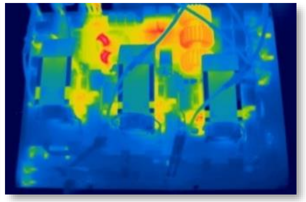
Business Area - Power Electronics, Grids and Smart Systems
Center for Power Electronics and Sustainable Grids



- **Development of converter systems for the energy and mobility transition**
  - Development and evaluation of innovative converter systems
  - Focus on efficient and cost-optimized systems with latest technologies

- **Typical topics**
  - Increase of power density by innovative design concepts and efficient circuit topologies
  - Multifunctional properties with regard to control technology and device-specific standards
  - Multifunctional properties with regard to control technology and device-specific standards (Time-to-Market)





Our laboratory offers unique opportunities in the field of power electronics and dynamic grid control

Conclusion

- Electric mobility is finally ready for mass market
- EV storage capacity is interesting on the short term (peak shaving), not on the long scale (balancing)
- PV own consumption and especially peak shaving is economically interesting for ev owners – if driving profile fits – and pooling

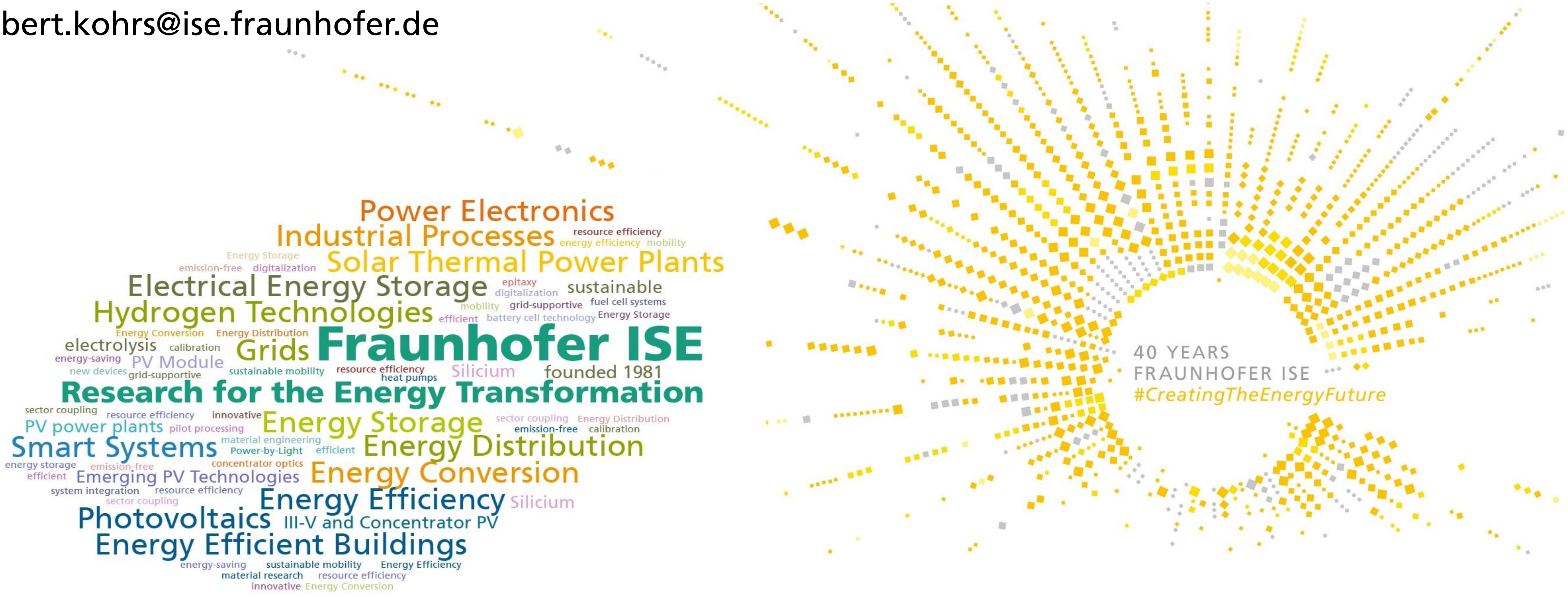
- EV induced problems expected in distribution grids with higher charging power demand
- Fleet management or on-board grid sensing are viable options to avoid grid enforcement

Thank You for Your Attention!

https://s.fhg.de/SmartGrids

Dr. Robert Kohrs

www.ise.fraunhofer.de
robert.kohrs@ise.fraunhofer.de



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